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TECHNICAL REPORT NO. 10456

M4 EXPANSIBLE VAN BODY
PHYSICAL TEST OF
AIRCRAFT TIE-DOWN AND LIFTING EYES

FEBRUARY 1969



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MILLER TRAILERS, INC.

TACOM

CONTRACT NO. DAAE07-68-C-1133

DEVELOPMENT & ENGINEERING DIRECTORATE
U.S. ARMY TANK AUTOMOTIVE COMMAND Warren, Michigan

20020813068

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TECHNICAL REPORT NO. 10456

M4 EXPANSIBLE VAN BODY
PHYSICAL TEST OF
AIRCRAFT TIE-DOWN AND LIFTING EYES

by

C. Blair
Miller Trailers Project Engineer

test held at

Miller Trailers, Inc. Bradenton, Florida

from

3 February 1969 thru 7 February 1969

FEBRUARY 1969

ACKNOWLEDGEMENT

The program was authorized by the U. S. Army Tank Automotive Command (TACOM), Warren, Michigan under Contract No. DAAE07-68-C-1133. Test Director was Mr. Paul Kelps, project engineer of the Trailer Branch, Development & Engineering Directorate.

ABSTRACT

The van body tie-down test was performed on a smooth, level, concrete slab containing a fixed group of permanent anchors set in the concrete, each equipped with a heavy attaching ring. The four anchors used in the test agree closely with the spacing of tie-down rings in the C-124 aircraft.

For the lifting test, sling cables were attached at each end of a longitudinal spreader bar directly over the lifting eyes. Gradually increasing equal pressure was applied through hydraulic actuators. The van floor was loaded with successively greater weights, to simulate 2.0G's.

Subsequently, the body sides were opened to full expanded position, and then re-closed. These operations proceeded smoothly, with no evidence of binding.

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ATTENDEES:

- | | |
|---------------------|--|
| 1. P. KELPS | U. S. ARMY PROJECT ENGINEER, AMSTA-REL |
| 2. J. FOSTER | MARTIN - ORLANDO - M/O |
| 3. F. FISCHER | TECOM |
| 4. C. KNAPPENBERGER | MARTIN - ORLANDO - M/O |
| 5. J. McCAULEY | AMCPM - GPV |
| 6. E. ROACH | MICOM - PPMO |
| 7. J. HAWBLITZEL | MILLER TRAILERS PROJECT MANAGER |
| 8. C. BLAIR | MILLER TRAILERS PROJECT ENGINEER |
| 9. R. B. GLADEN | MILLER TRAILERS VICE PRESIDENT |

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M4 BODY TIE DOWN AND LIFTING TESTS

PERFORMED AT MILLER TRAILERS, INC. FACILITY AT BRADENTON, FLORIDA, 4, 5, 6 & 7 FEBRUARY 1969. FILE 1053-45

AUTHORIZATION: USATAC WORK DIRECTIVE 1133-313-16

PURPOSE AND PROGRAMMING: AS OUTLINED IN MINUTES OF PRE-TEST CONFERENCE HELD 10 DECEMBER 1968 AT MARTIN-MARIETTA CORPORATION, ORLANDO DIVISION.

TEST SITE AND EQUIPMENT: TEST WAS PERFORMED ON A SMOOTH, LEVEL CONCRETE SLAB, CONTAINING A FIXED GROUP OF PERMANENT ANCHORS SET IN THE CONCRETE, EACH EQUIPPED WITH A HEAVY ATTACHING RING. THE FOUR ANCHORS USED IN THE TEST AGREE CLOSELY WITH THE SPACING OF HEAVY DUTY TIE DOWN RINGS IN THE C-124 AIRCRAFT.

STEEL WIRE ROPES WITH THIMBLES AND APPROPRIATE HOOKS WERE USED TO APPLY THE VARIOUS PULL LOADS TO THE BODY.

POWER WAS APPLIED THROUGH TWO HYDRAULIC ACTUATORS INSERTED IN THE CABLES AT ONE END OF THE BODY. WITH THE BODY FREE TO ROLL ON STEEL ROLLERS, THE PULL IN POWERED CABLES WAS DUPLICATED IN THE PLAIN CABLES AT OPPOSITE END OF BODY.

THE SOURCE OF POWER FOR TIE DOWN TESTS WAS AN ELECTRICALLY DRIVEN HYDRAULIC PUMP, FITTED WITH PRESSURE GAUGE GRADUATED IN 100 P.S.I. INCREMENTS, AND CAPABLE OF REACHING 10,000 P.S.I.

THE HYDRAULIC ACTUATORS USED WERE OF 6 INCHES INSIDE DIAMETER, HAVING A 7 INCH STROKE AND 2 INCH DIAMETER PISTON ROD. SINCE THE POWER WAS APPLIED ON THE ROD SIDE OF THE PISTON, THE EFFECTIVE AREA UNDER PRESSURE WAS $.7854 (6)^2 - .7854 (2)^2 = 25.13$ SQ. IN.

THE LIFTING TEST WAS PERFORMED WITH A SINGLE PORTABLE CRANE, WITH THE LIFTING HOOK ATTACHED AT THE CENTER OF A LONGITUDINAL SPREADER BAR. THE SLING CABLES DESCRIBED UNDER "SECOND TEST" WERE ATTACHED AT EACH END OF THE SPREADER BAR, DIRECTLY OVER THE LIFTING EYES ON THE VAN BODY.

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M4 BODY TEST

4 FEBRUARY 1969 - FIRST TEST, USING LIFTING EYES AS TIE DOWN POINTS, PER MILLER DRAWING 1052-32-100.

BODY WAS LOCATED ON TEST SITE AND SUPPORTED ON STEEL ROLLERS. WITH SPECIAL OUTBOARD ADAPTERS MOUNTED IN PLACE OF THE FORWARD LIFTING EYES, STEEL CABLES WERE RIGGED TO PERMANENT ANCHORS IN THE CONCRETE SLAB, WITH A HYDRAULIC ACTUATOR INCORPORATED IN EACH OF THE TWO CABLES FROM THE FORWARD EYES. THE ANGULARITY OF BOTH FORWARD AND REAR CABLES WAS 35 DEGREES FROM VERTICAL, DICTATED BY THE LOCATION OF PERMANENT ANCHORS.

GRADUALLY INCREASING EQUAL PRESSURE WAS APPLIED SIMULTANEOUSLY TO THE HYDRAULIC ACTUATORS, UNTIL A PRESSURE OF 400 P.S.I. WAS REACHED.

INSPECTION OF EACH EYE SHOWED DISTRESS ONLY AT THE L.H. REAR, WHERE THE UPPER EDGE OF THE MOUNTING FLANGE SEPARATED FROM THE BODY SKIN APPROXIMATELY 1/16 INCH. ALL THREE BOLTS HOLDING THIS EYE IN PLACE WERE FOUND TO BE LOOSE, WITH A BROKEN LOCKWASHER AT ONE. THESE BOLTS ARE MADE FROM VERY SOFT STEEL, WITH NO HEAD MARKINGS. SINCE THE SEATING FACE OF ONE BOLT HAD BEEN DESTROYED, IT WAS REPLACED WITH A GRADE 5 BOLT, AND ALL BOLTS AND NUTS AT EACH LIFTING EYE WERE TORQUED TO 100 FT. LBS. THE TEST WAS THEN REPEATED, WITH NO FURTHER FAILURES EVIDENT.

SINCE THE HYDRAULIC ACTUATORS USED HAVE A NET PISTON AREA OF 25.13 SQ. IN., THE 400 P.S.I. USED APPLIED A PULL OF 10,050 LBS. AT EACH FRONT CABLE. WITH EQUAL ANGULARITY AND THE BODY RESTING ON ROLLERS, THE SAME PULL WAS TRANSFERRED TO THE REAR. AT THE 35 DEGREE ANGLE, THE 10,000 LB. PULL HAS AN 8190 LB. VERTICAL COMPONENT, AND 5735 LB. HORIZONTAL COMPONENT.

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M4 BODY TEST (CONTINUED)

5 FEBRUARY 1969 - SECOND TEST, USING LIFTING EYES FOR LIFTING TEST, TO SIMULATE 2.0 G'S. SCALE WEIGHT OF EMPTY BODY WITH ADAPTER 9,370 LBS.
REFERENCE: MILLER DRAWING NO. 1053-45

THE HOOK OF A PORTABLE LIFTING CRANE, WITH A LONGITUDINAL SPREADER BAR, WAS POSITIONED OVER THE CENTER OF THE VAN BODY. CABLE SLINGS WERE RIGGED FROM EACH END OF THE SPREADER BAR TO THE FORWARD AND REAR LIFTING EYES ON THE BODY.

THE INDIVIDUAL SLINGS AT THE FRONT WERE AT AN ANGLE OF 32 DEGREES FROM VERTICAL, AND AT THE REAR, THE ANGLE FROM VERTICAL WAS 18 DEGREES, 30 MINUTES.

AN INITIAL LOAD OF 4158 LBS. WAS PLACED ON THE VAN BODY FLOOR, COVERING APPROXIMATELY 48 INCHES CENTRALLY OF THE FLOOR WIDTH, AND EVENLY DISTRIBUTED LONGITUDINALLY. THIS GROSS LOAD WAS LIFTED WITH NO SIGN OF DISTRESS.

TOTAL LOAD WAS THEN INCREASED TO 6158 LBS., AND AGAIN LIFTED. THERE WAS NO EVIDENCE OF DISTRESS.

WITH TOTAL LOAD OF 8158 LBS., COVERING FULL WIDTH OF VAN FLOOR, INSPECTION AFTER LIFT SHOWED A SLIGHT SEPARATION AT THE LOWER HALF OF SKIN VERTICAL LAPS, APPROXIMATELY 1/32 INCH, ON ROADSIDE OF BODY, AND A SLIGHT DEFORMATION OF THE HONEY COMB STRUCTURE IMMEDIATELY UNDER THE FLOOR PAN.

WHEN THE LOAD WAS INCREASED TO 10,158 LBS., AND LIFTED, A FURTHER INCREASE WAS NOTED IN THE SKIN LAP SEPARATION, AS WELL AS A SLIGHT SAG AT THE CENTER OF THE WHOLE STRUCTURE. THIS SAG DISAPPEARED WHEN THE LOAD WAS REMOVED.

AT THIS POINT, IT WAS DECIDED BY ATTENDING USATAC PERSONNEL THAT ONLY 1,500 LBS. ADDITIONAL WEIGHT WOULD BE ADDED, BRING THE TOTAL FLOOR WEIGHT TO 11,658 LBS., IN ORDER TO AVOID PERMANENT DAMAGE TO THE BODY WHICH WAS NOT DESIGNED TO CARRY SO EXCESSIVE A FLOOR LOAD.

WHEN LIFTED WITH 11,658 LBS. LOAD, THERE WAS NO FURTHER EVIDENCE OF DISTRESS, AND THE TEST ENDED WITH THIS LIFT.

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M4 BODY TEST (CONTINUED)

- 5 FEBRUARY 1969 -

BASED ON THE 11,680 LBS. GIVEN IN MINUTES OF PRE-TEST
MEETING 10 DECEMBER 1968 AS THE WEIGHT OF LOADED VAN
BODY WITH ADAPTER, THE FINAL LIFTED WEIGHT REPRESENTS
 $\frac{9,370 + 11,658}{11,680} = 1.8 \text{ G'S}$, WHICH WAS DEEMED SUFFICIENT
BY USATAC PERSONNEL.

SUBSEQUENTLY, THE BODY SIDES WERE OPENED TO THE FULL
EXPANDED POSITION, AND WERE THEN RE-CLOSED. THESE
OPERATIONS PROCEEDED SMOOTHLY AND NORMALLY, WITH NO
EVIDENCE OF BINDING.

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M4 BODY TEST

4, 5, 6, & 7 FEBRUARY 1969 - THIRD TEST: TESTING TIE DOWN "U" BOLTS IN VAN BODY SKIDS, SIMULATING AIRCRAFT LOADING TIE DOWN. EACH "U" BOLT TO BE LOADED TO 20,000 LBS. CABLE TENSION. REFERENCE MILLER DRAWING 1052-32-101

BODY WAS LOCATED ON TEST SITE, SUPPORTED ON ROLLERS, IN SAME POSITION AS FOR FIRST TEST. IN THIS POSITION, THE ANGLE OF PULL ON THE END RESTRAINING CABLES VERY CLOSELY APPROXIMATES THE SITUATION IN THE C-124 AIRCRAFT, BUT IS ONLY 15°-30' AT THE CENTER "U" BOLT.

THE FIRST PHASE OF THIS TEST INVOLVED THE FOUR END "U" BOLTS, TWO AT FRONT AND TWO AT REAR, WITH PLAIN CABLES ATTACHED AT FRONT AND HYDRAULIC ACTUATORS IN THE REAR CABLES. WHEN THE TEST LOAD WAS APPLIED AT EACH ACTUATOR, THE TWO FRONT "U" BOLTS SHOWED NO SIGNS OF DISTRESS, BEYOND A SLIGHT BENDING DEFORMATION IN THE "U" CONFIGURATION.

HOWEVER, BOTH REAR "U" BOLTS SHOWED EXCESSIVE BENDING, AND APPROXIMATELY 3/16" "PULL OUT" OF THE WEB OF THE SKID RAIL CHANNEL, ALSO BENDING OF THE 3/16" THICK REINFORCING PLATE UNDER THE NUTS AT INNER ENDS OF THE "U" BOLT LEGS. INVESTIGATION SHOWED THAT THE BODY OF THE HYDRAULIC ACTUATOR WAS INTERFERING WITH THE ADAPTER BRACKETS, FORMING A LEVERAGE SYSTEM WHICH GENERATED A GREAT AMOUNT OF TRANSVERSE LOAD AT THE "U" BOLT, THUS ACCOUNTING FOR THE "PULL OUT" OF THE CHANNEL WEB, AS WELL AS EXCESSIVE DEFORMATION OF THE INNER PLATE.

AT THIS POINT TESTING WAS HALTED, AND THE DEFORMED CHANNEL WEBS AND REINFORCING PLATES WERE HAMMERED BACK TO THEIR ORIGINAL FLAT CONDITION. THE REAR "U" BOLTS WERE REMOVED AND CHECKED FOR HARDNESS ON A ROCKWELL HARDNESS TESTER, WHICH SHOWED THE "U" BOLT HARDNESS TO BE IN THE RANGE OF RC-33 TO 34. THE "U" BOLTS WERE THEN REWORKED COLD TO THEIR ORIGINAL SHAPE, AND REASSEMBLED TO THE VAN.

DUE TO FAILURE OF ONE OF THE HYDRAULIC ACTUATORS, IT WAS NECESSARY TO CONTINUE THE TEST WITH THE ONE REMAINING UNIT. THIS WAS RERIGGED AT THE APPROXIMATE CENTER OF THE CABLE FROM ROADSIDE REAR "U" BOLT, TO ELIMINATE ADAPTER BRACKET INTERFERENCE, AND A BALANCING

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M4 BODY TEST (CONTINUED)

4, 5, 6, & 7 FEBRUARY 1969

OPPOSITE CABLE WAS CONNECTED AT THE CURBSIDE CENTER "U" BOLT, LEADING FORWARD TO A PERMANENT ANCHOR.

800 PLUS P.S.I. PRESSURE WAS APPLIED AT THE ACTUATOR, WHICH DEVELOPED A 20,000 LB. PULL AT BOTH THE ROADSIDE REAR AND CURBSIDE CENTER "U" BOLTS. BEYOND A SLIGHT BENDING IN THE "U" BOLTS THEMSELVES, NO FAILURES WERE EVIDENT, AND THE TEST WAS CONSIDERED PASSED. ATTENDING USATAC PERSONNEL WAIVED THE NECESSITY OF TESTING THE ROADSIDE CENTER "U" BOLT.

RECOMMENDATIONS:

1. THAT NO M4 VAN BODY SHALL PASS FINAL INSPECTION UNLESS SAE GRADE 5 BOLTS AS SPECIFIED ON ORDNANCE DRAWINGS, PROPERLY TORQUED, ARE USED TO MOUNT THE FOUR LIFTING EYES.
2. THAT THE REINFORCING PLATES ON INSIDE OF SKID CHANNELS AT EACH "U" BOLT BE INCREASED IN THICKNESS, LENGTH AND WIDTH, WITH EACH END WELDED TO THE CHANNEL WEB.

BY C. S. Miller DATE 24 JAN. '69

SUBJECT M4 BODY

SHEET NO. 1 OF 1

CHKD. BY DATE

RESTRAINT CALCS. FOR TIE DOWN

JOB NO. 1053-45

MILLER TRAILERS, INC.

PROPOSAL IN C-124 AIRCRAFT

REF. MILLER DWG.

333 - 6th AVENUE, WEST
BRADENTON, FLORIDA 33505

DATED 24 JAN. '69

1. FORWARD RESTRAINT:

ASSUME ALL TIE CHAINS AT 25° - 50° FROM CENTERLINE

THIS IS THE MEAN OF 3 ANGLES RANGING BETWEEN 25° & 27° - 30° .

ASSUME 8 G'S RESTRAINT REQUIRED

$$8(11,680) = 93,540 \text{ TOTAL RESTRAINT REQ'D.}$$

$$93,540 \div 6 = 15,590 \text{ RESTRAINT EACH TIE (|| TO } \phi \text{)}$$

$$\frac{15,590}{\cos 25^{\circ}-50^{\circ}} = 17,300 \text{ LBS. ACTUAL TENSION EACH TIE AT 8 G'S.}$$

2. REARWARD RESTRAINT: - 8 G'S

ASSUME ALL TIE CHAINS AT 28° - 40° FROM CENTERLINE

THIS IS MEAN OF 3 ANGLES RANGING FROM 25° - 30° TO 33°

$$\frac{15,590 \text{ (AS ABOVE)}}{\cos 28^{\circ}-40^{\circ}} = 17,750 \text{ ACTUAL TENSION EACH TIE AT 8 G'S.}$$

3. LATERAL RESTRAINT: ASSUME 1.5 G'S REQ'D.

ASSUME ALL TIE CHAINS AT 27° - 45° . THIS IS MEAN OF SIX ANGLES RANGING FROM 25° TO 33° .

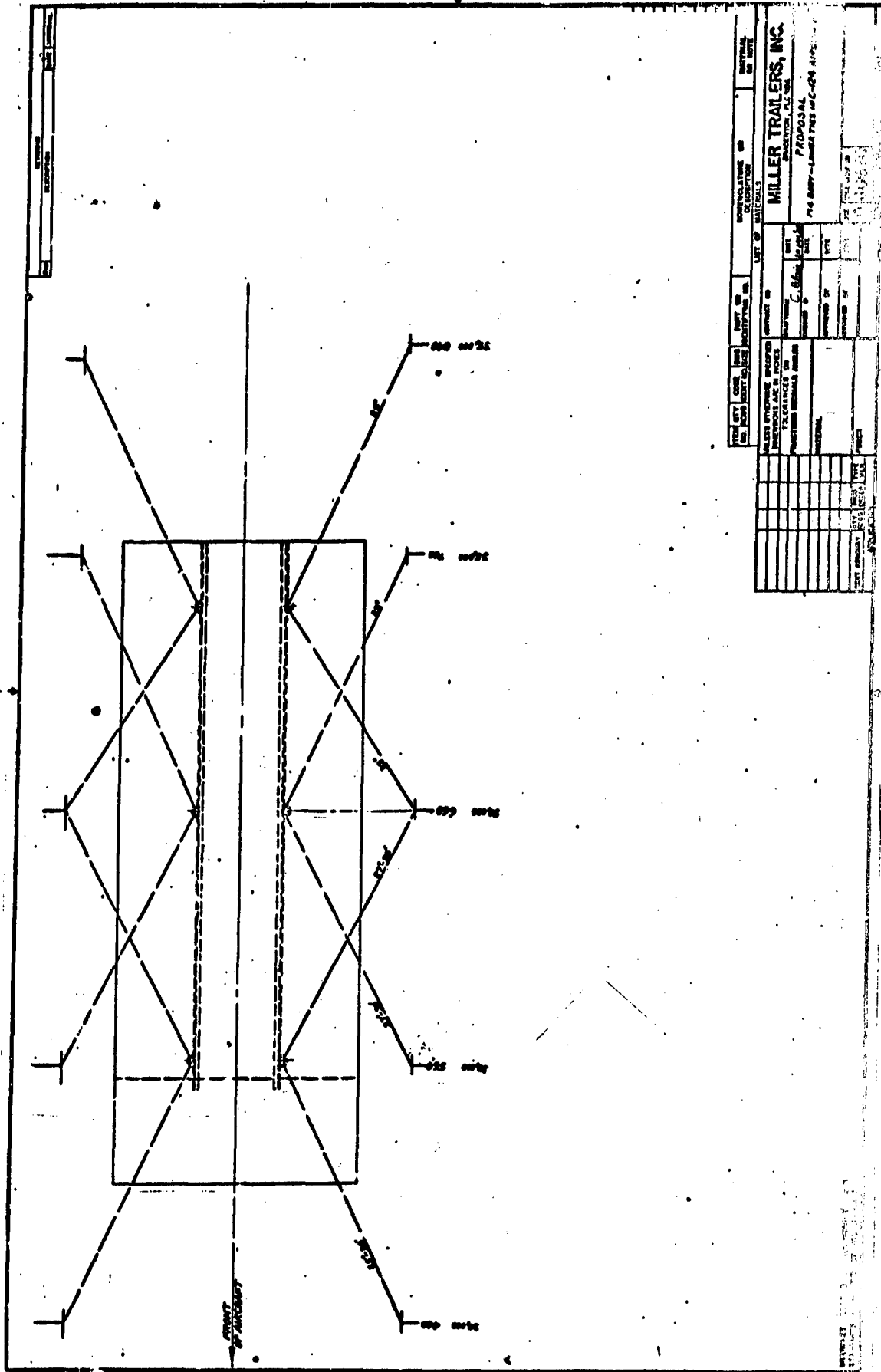
$$1.5(11,680) = 17,520 \text{ LBS. TOTAL RESTRAINT REQ'D.}$$

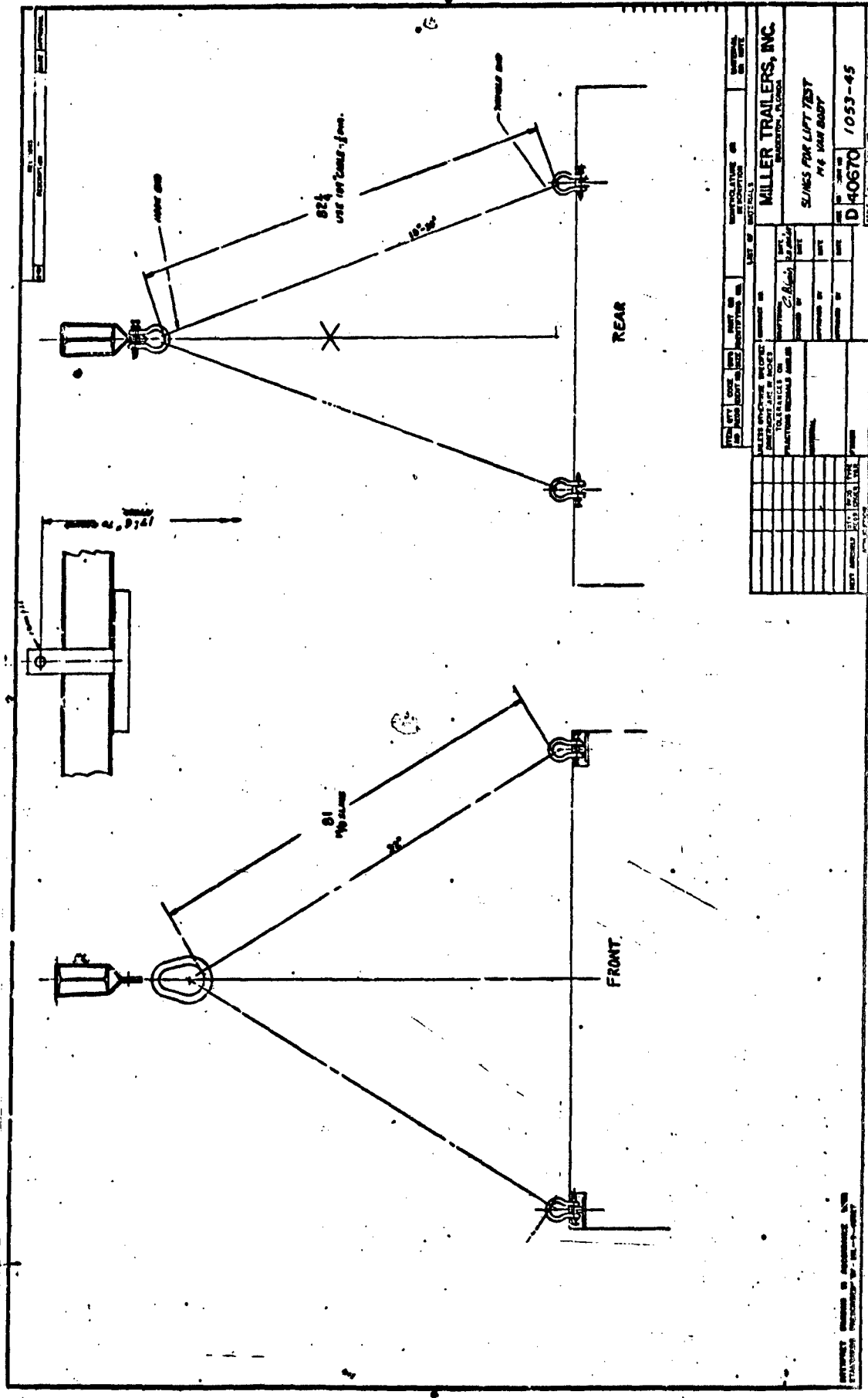
$$17,520 \div 6 = 2,920 \text{ LBS. RESTRAINT EACH TIE (}\perp\text{ TO } \phi \text{)}$$

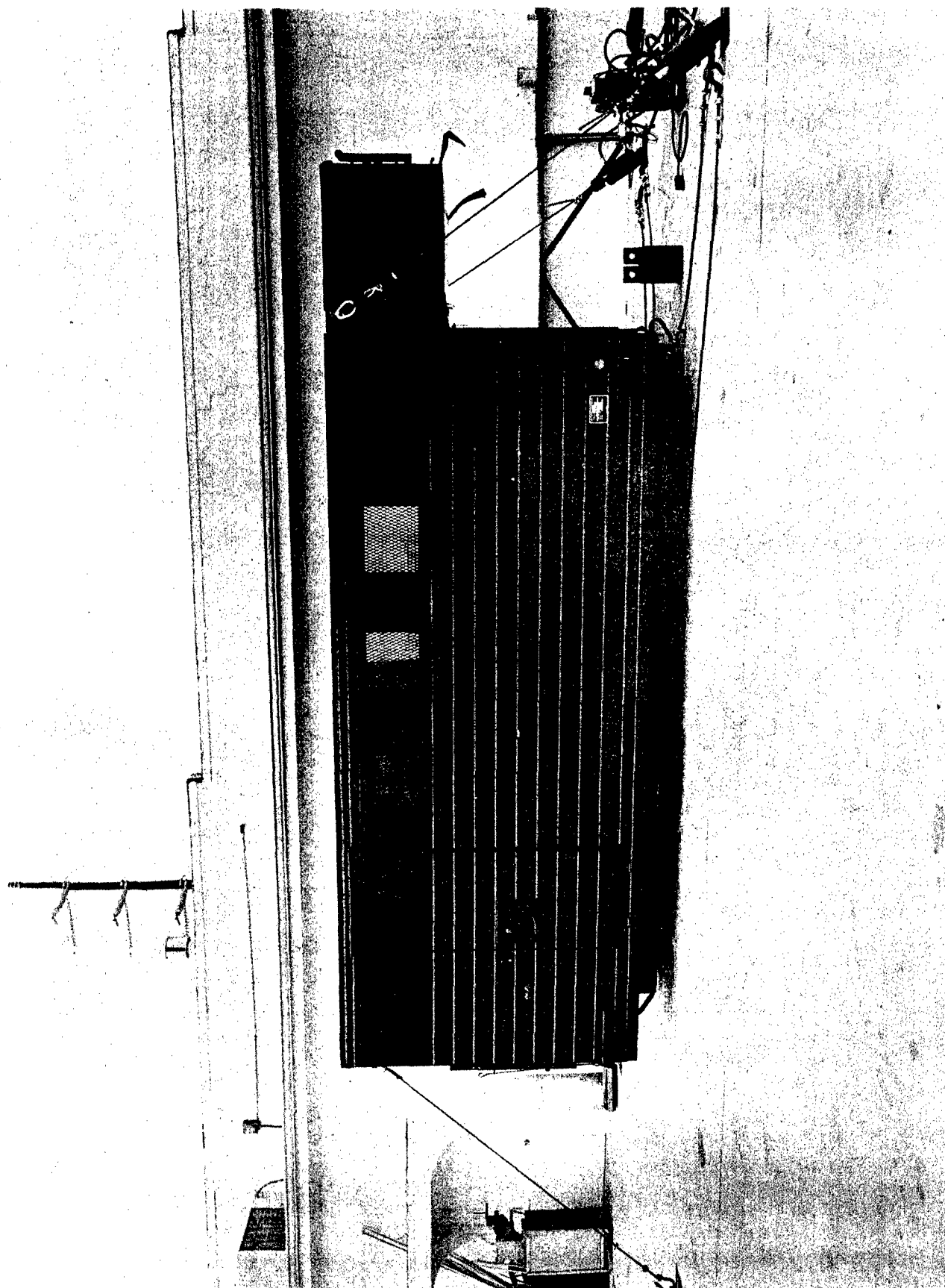
$$\frac{2,920}{\sin 27^{\circ}-45^{\circ}} = 6,250 \text{ LBS. ACTUAL TENSION EACH TIE AT 1.5 G'S}$$

APPENDIX

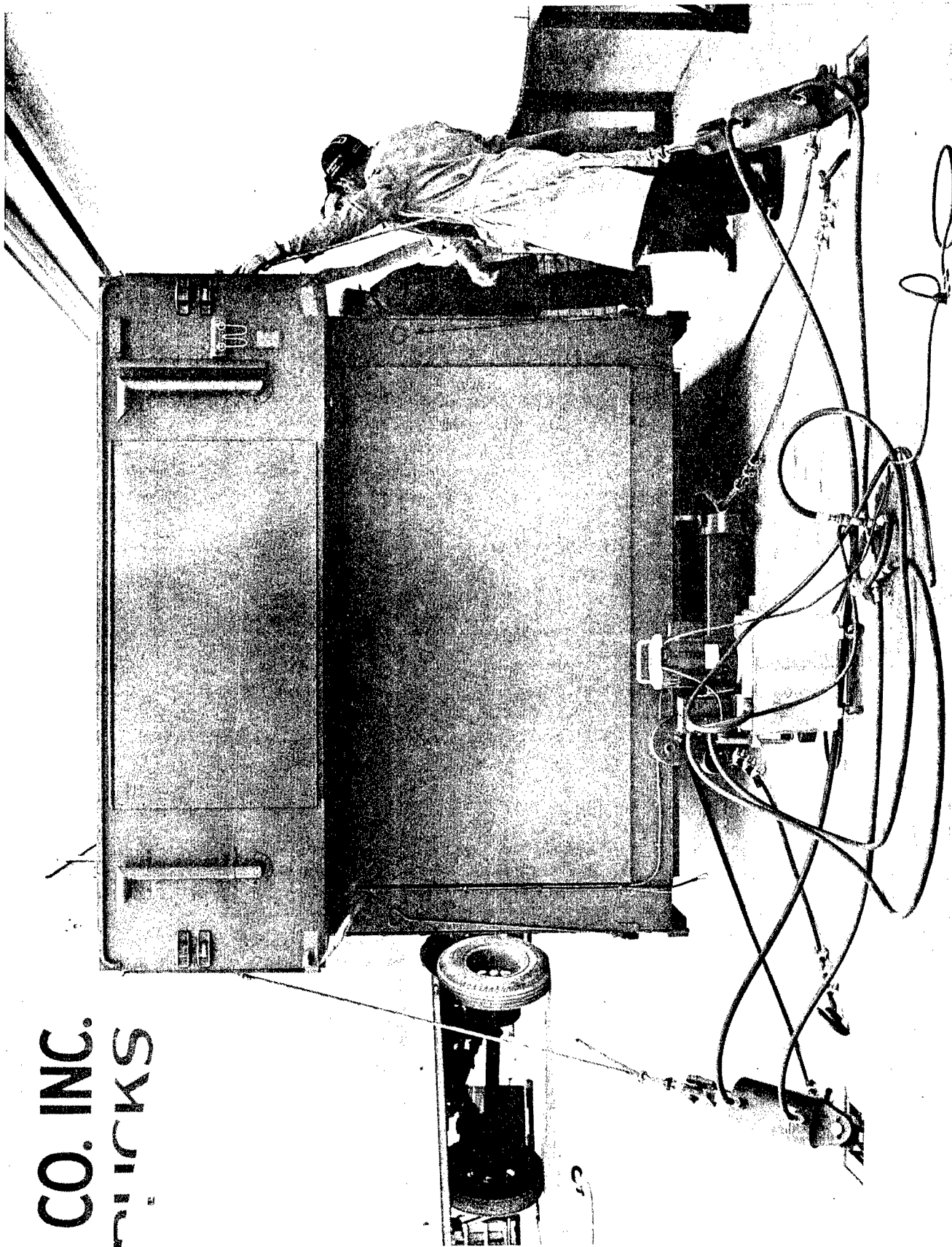


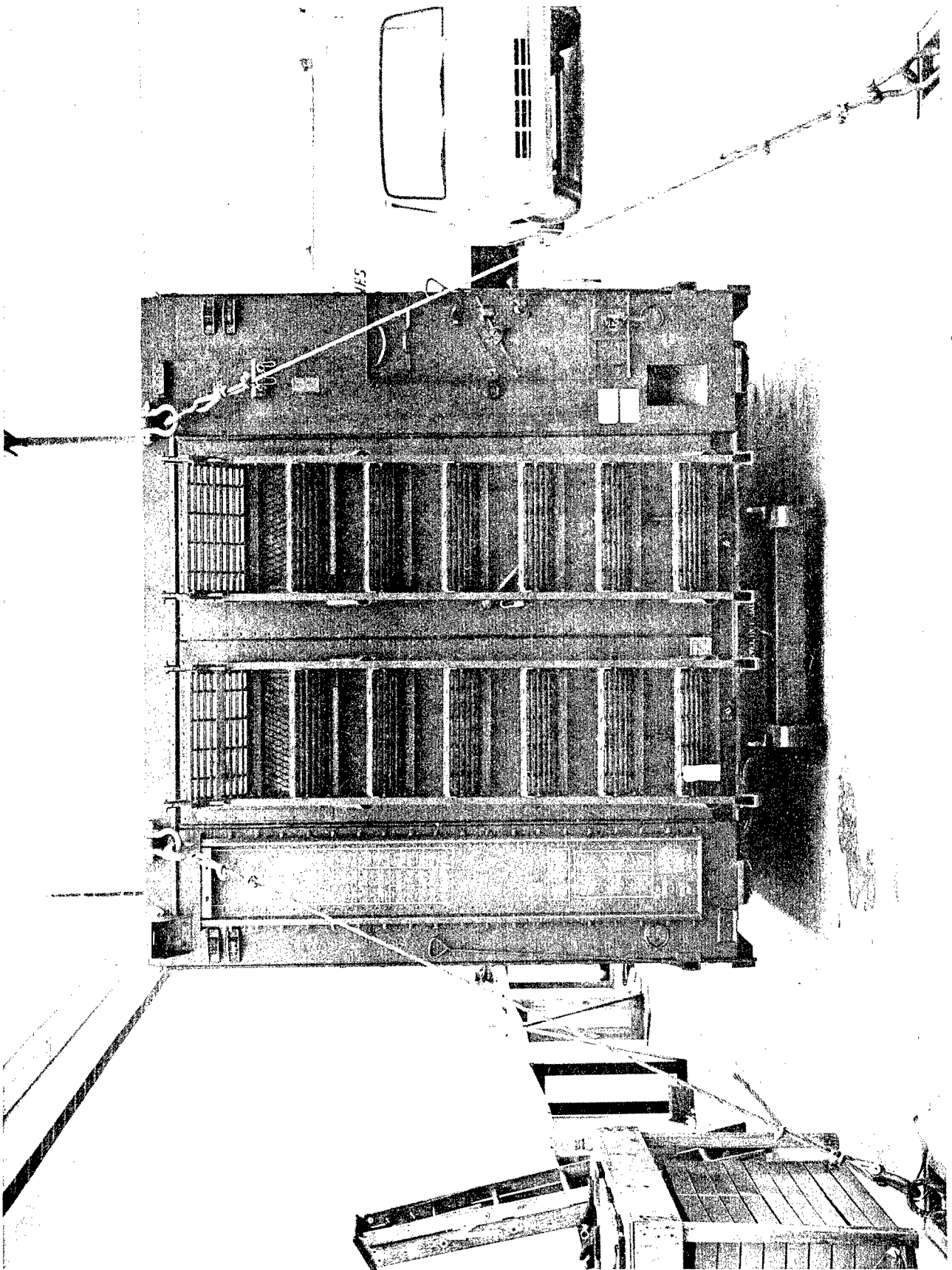


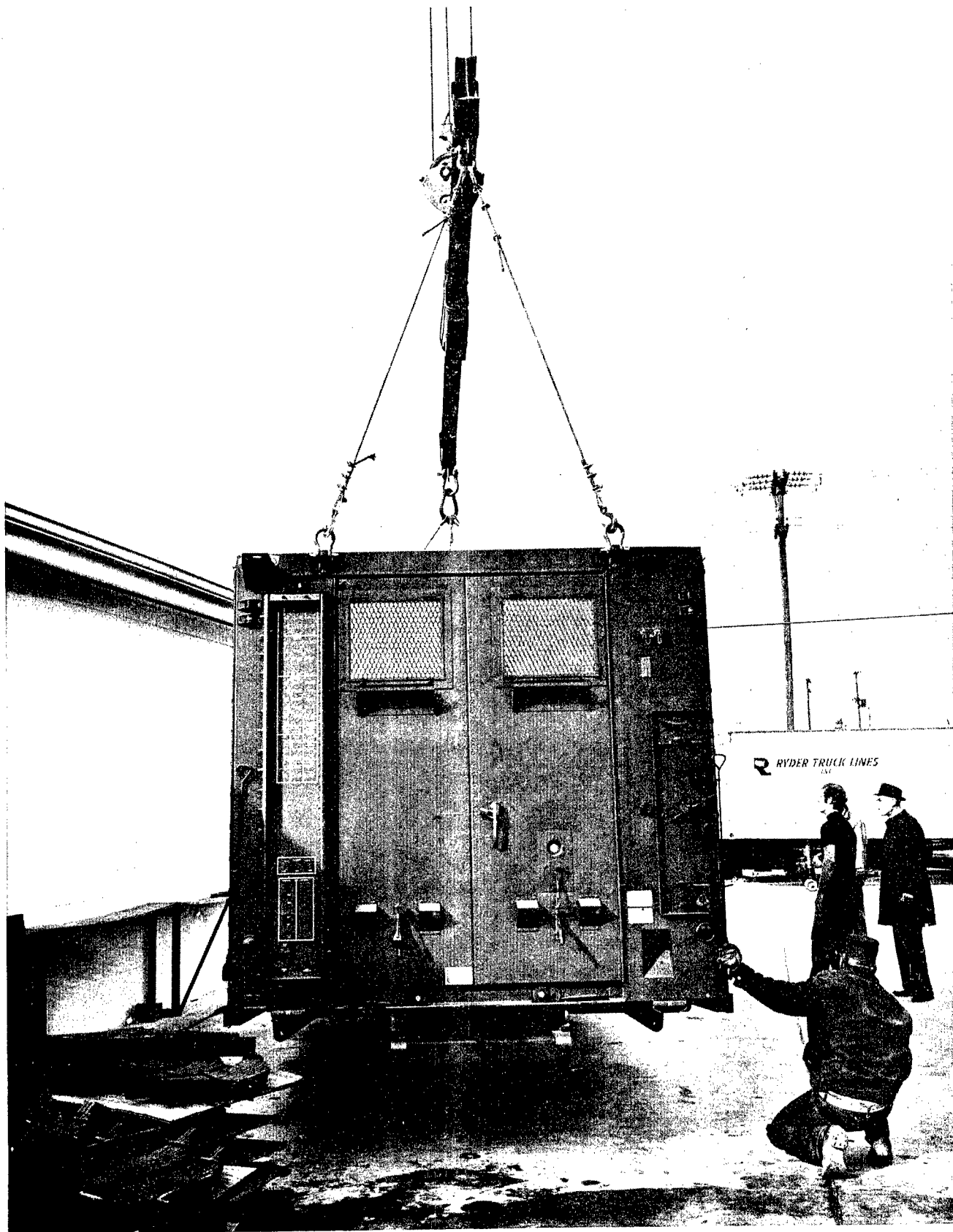


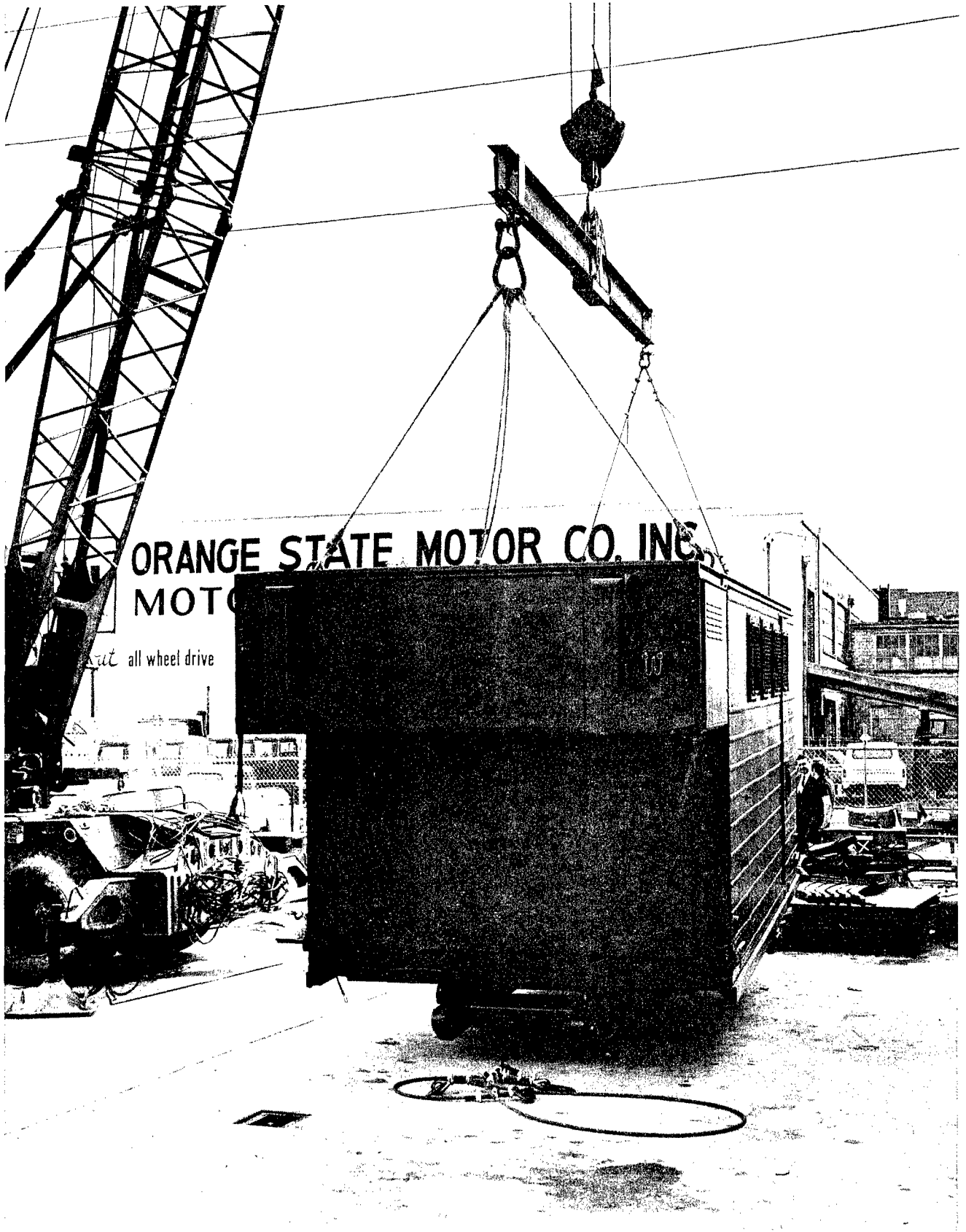


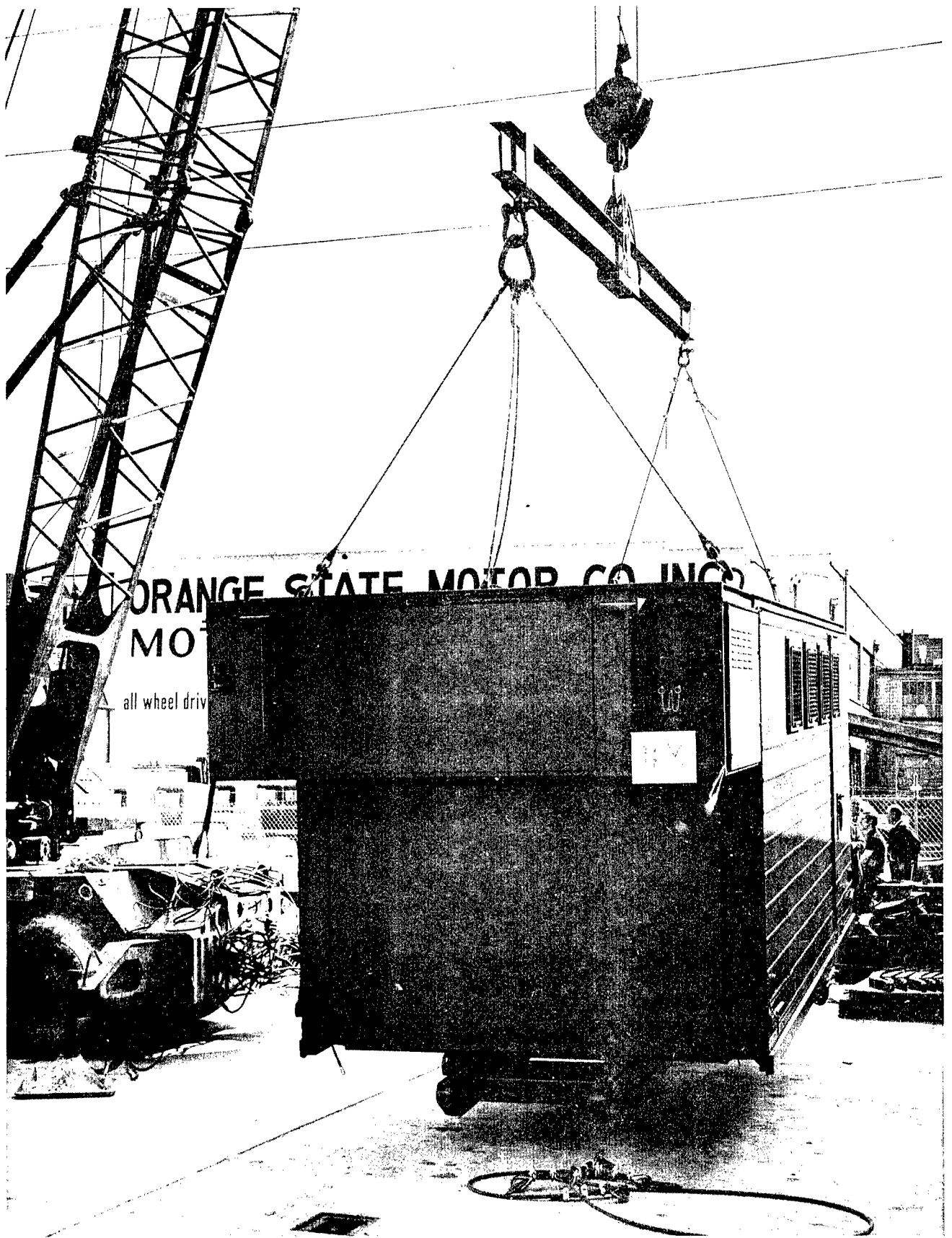
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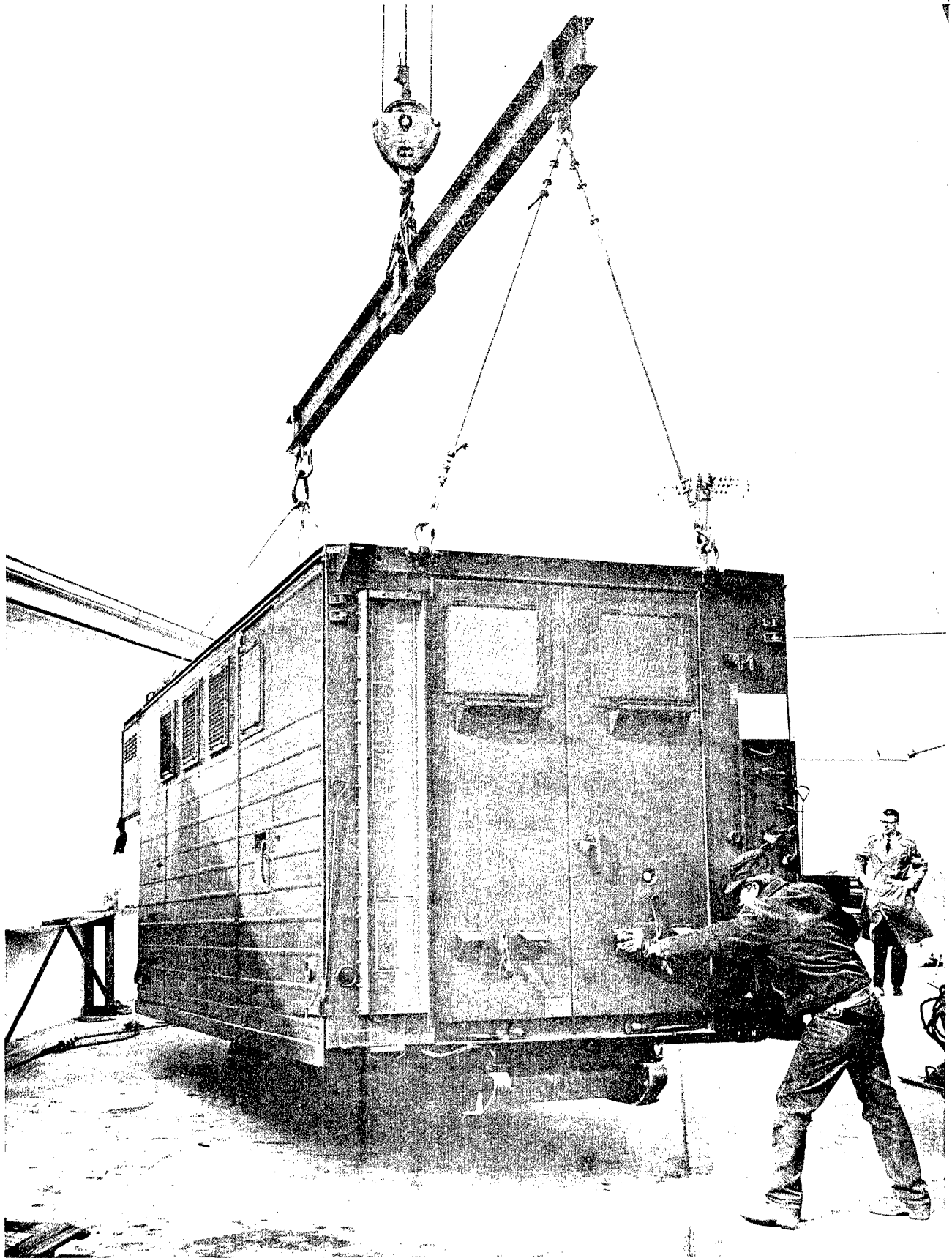






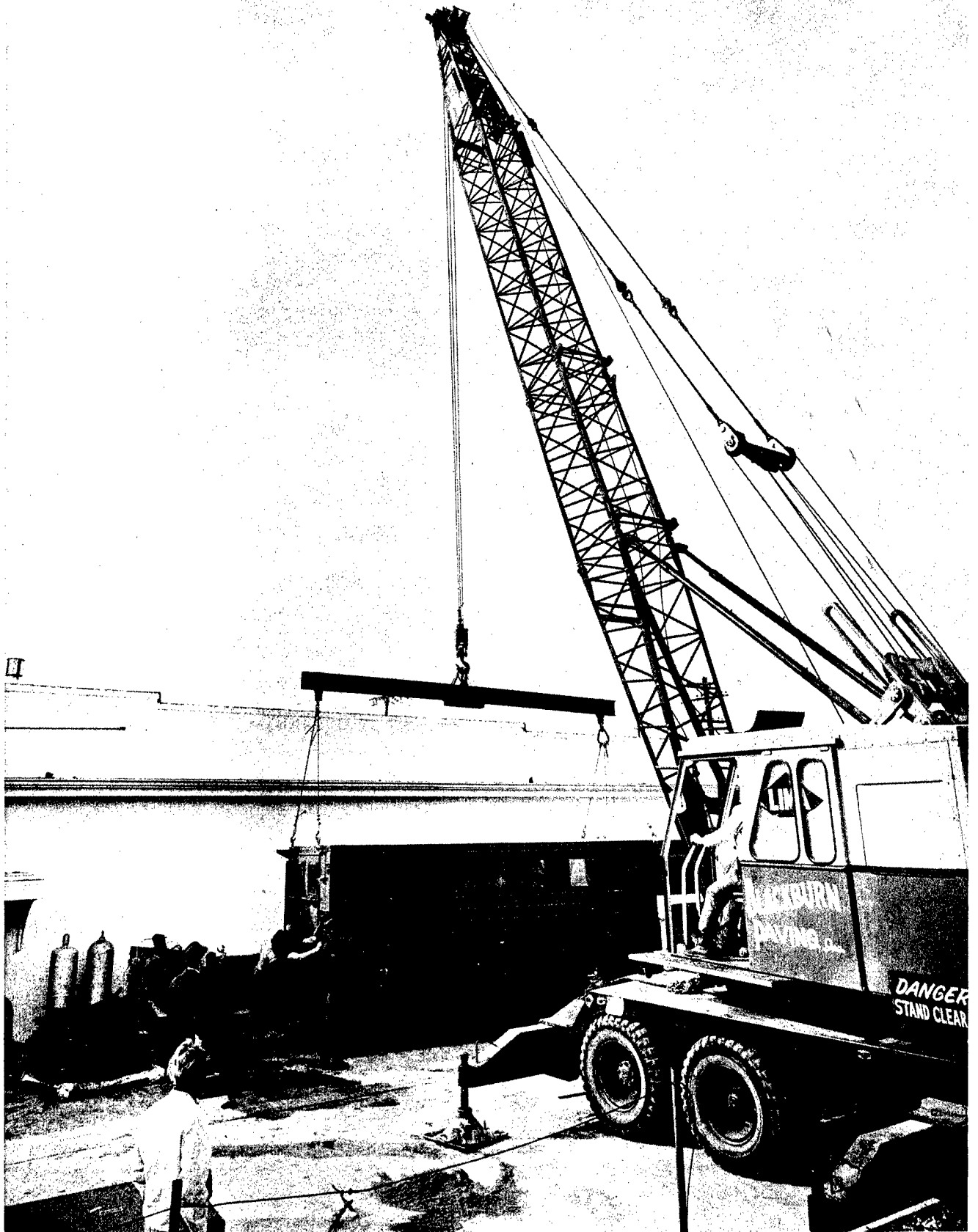




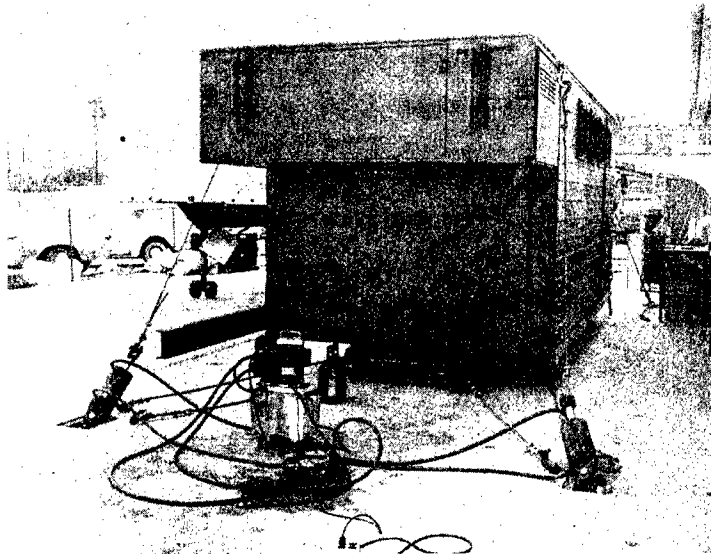








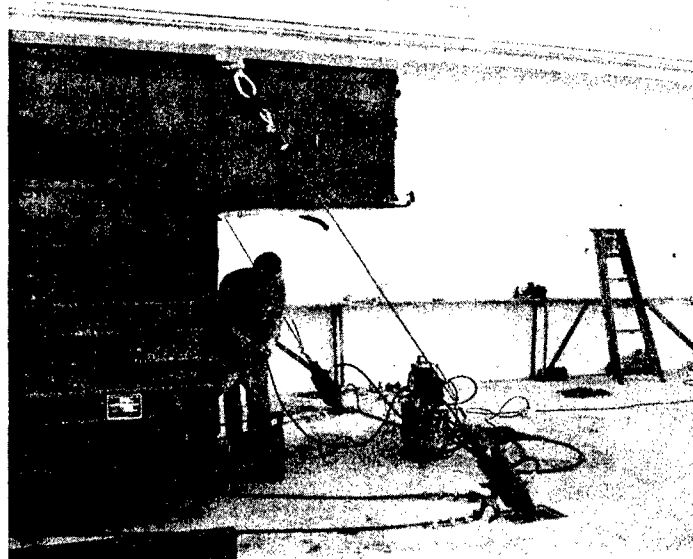
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M4 BODY TEST

UPPER TIE DOWN TEST AT 10,000lbs.

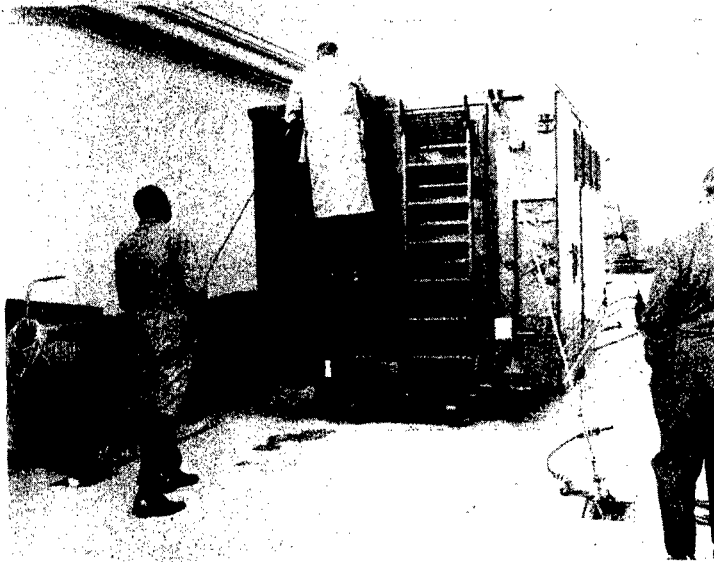
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M4 BODY TEST

UPPER TIE DOWN TEST AT 10,000lbs.

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M4 BODY TEST

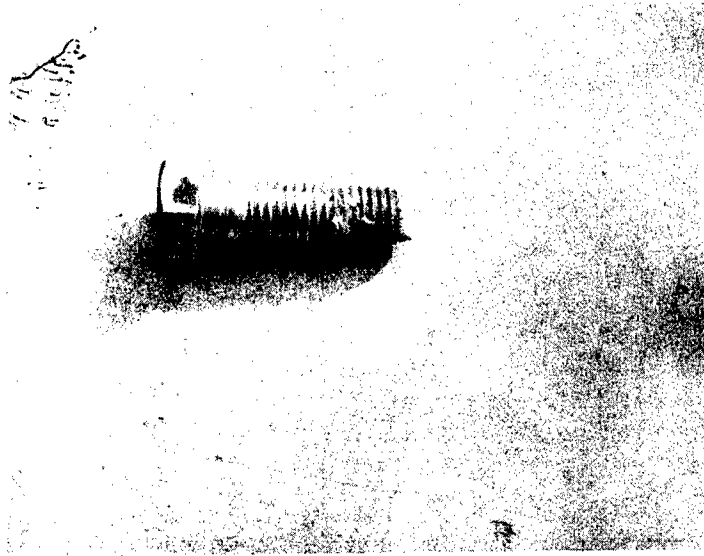
**INSPECTION OF UPPER TIE
DOWNS AND ROOF AFTER
10,000lb. TEST.**

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M4 BODY TEST

BOLT REMOVED AFTER UPPER
TIE DOWN TEST. THIS BOLT
WAS NOT A GRADE 5 BOLT.
NO VISIBLE DAMAGE.

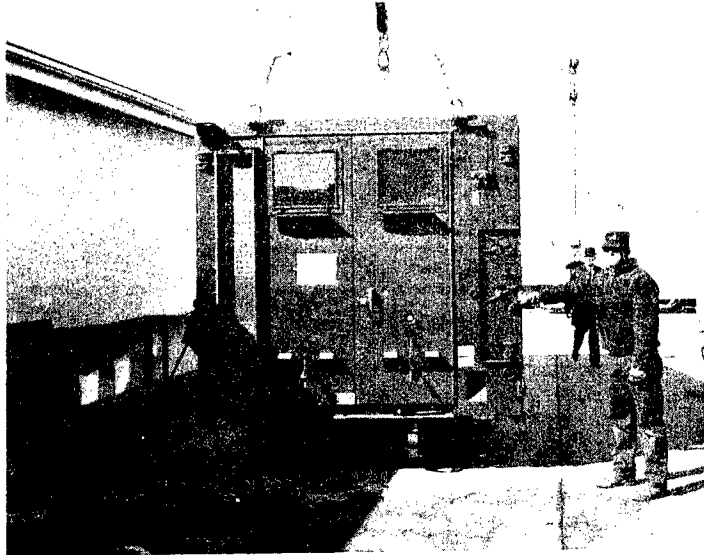
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M4 BODY TEST

**11,658LB. LOAD ADDED TO EMPTY VAN
FOR LIFT TEST.**

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M4 BODY TEST

LIFTING TEST AT 11,658LB. LOAD.

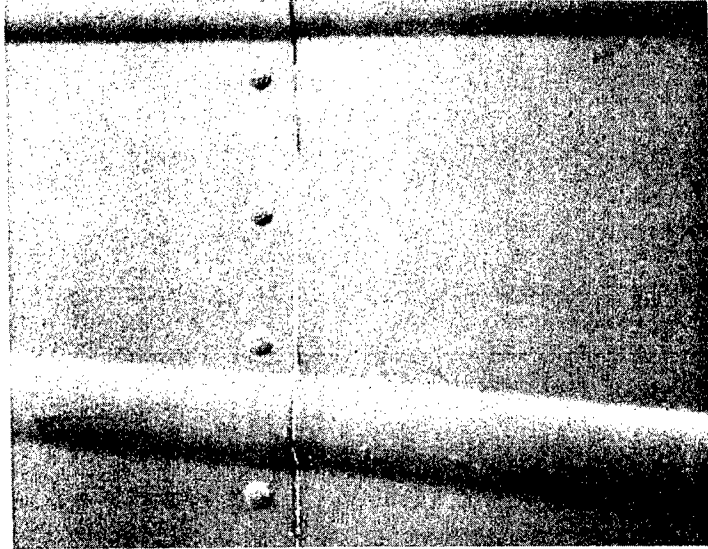
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M4 BODY TEST

SKIN SEPARATION AFTER 11,658LB.
LIFT TEST.

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M4 BODY TEST

**CLOSE UP, SKIN SEPARATION AFTER 11,658LB.
LIFT TEST.**

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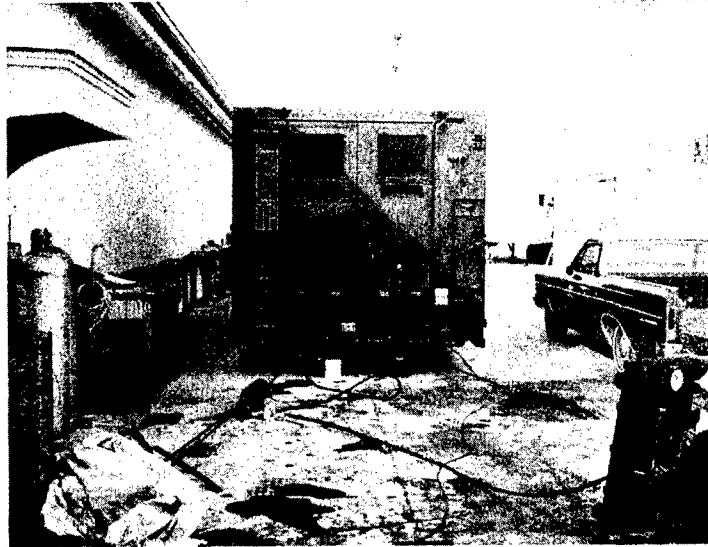


M4 BODY TEST

SKIN WARP DOWN LEFT SIDE AFTER

11,658LB. LIFT TEST.

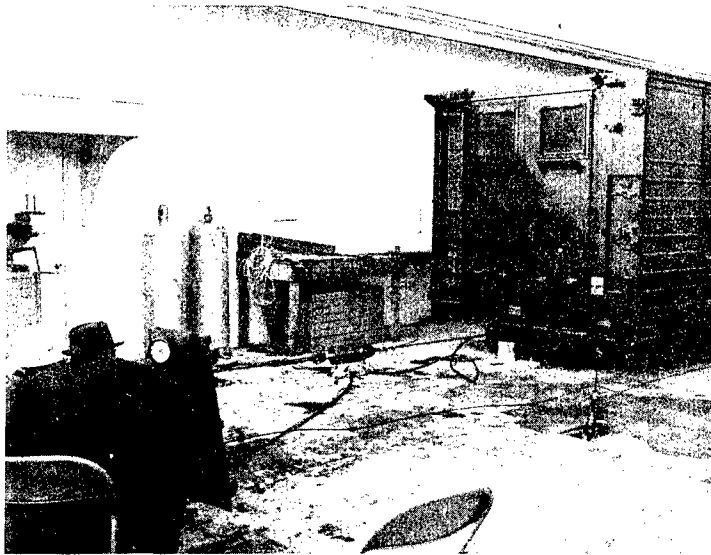
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M4 BODY TEST

LOWER TIE DOWN TEST AT
20,000lbs.

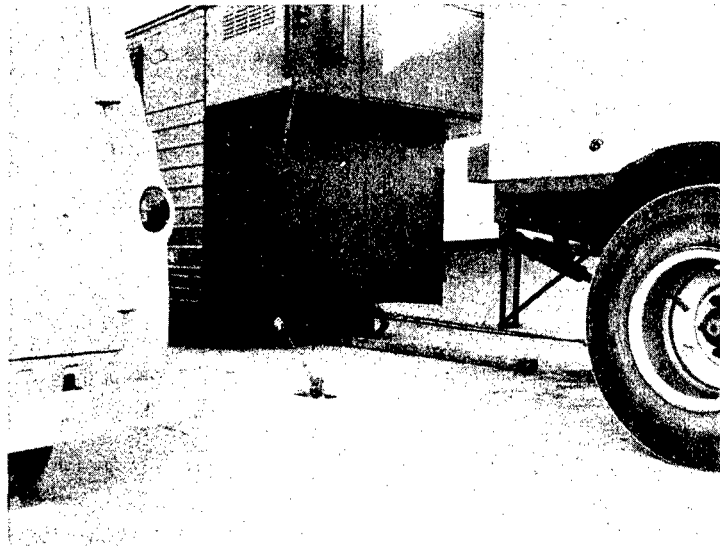
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M4 BODY TEST

LOWER TIE DOWN TEST AT
20,000lbs.

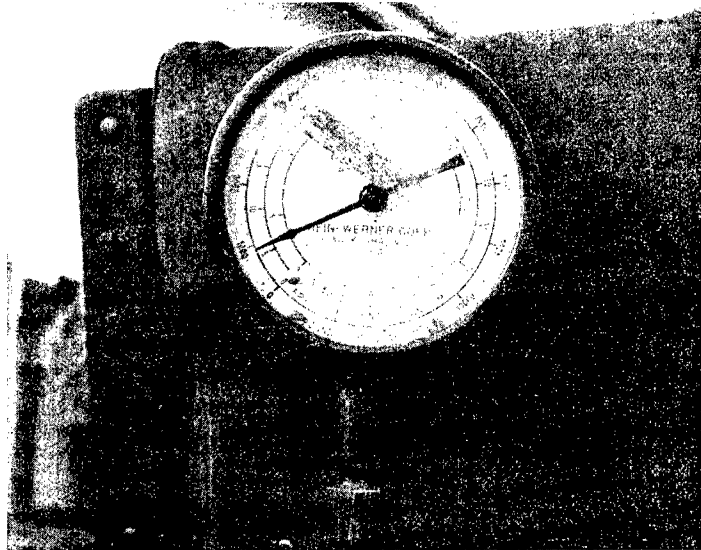
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M, BODY TEST

LOWER TIE DOWN TEST AT
20,000lbs.

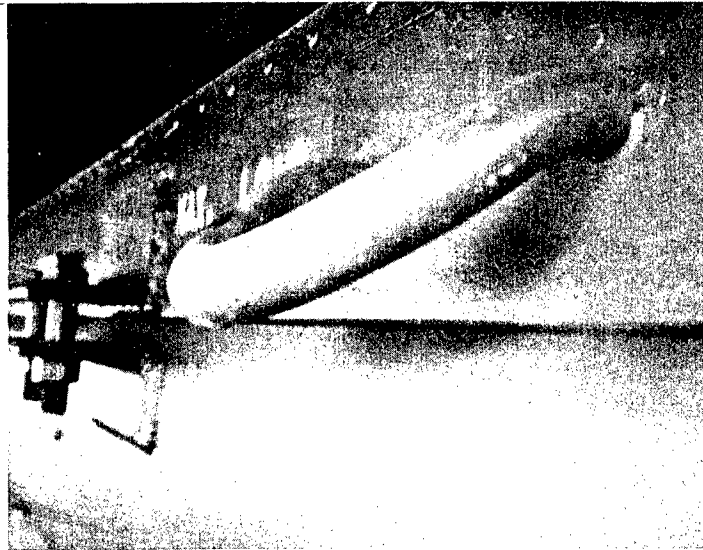
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M4 BODY TEST

GAUGE READING AT MAXIMUM
FOR 20,000lb. LOWER TIE
DOWN TEST.

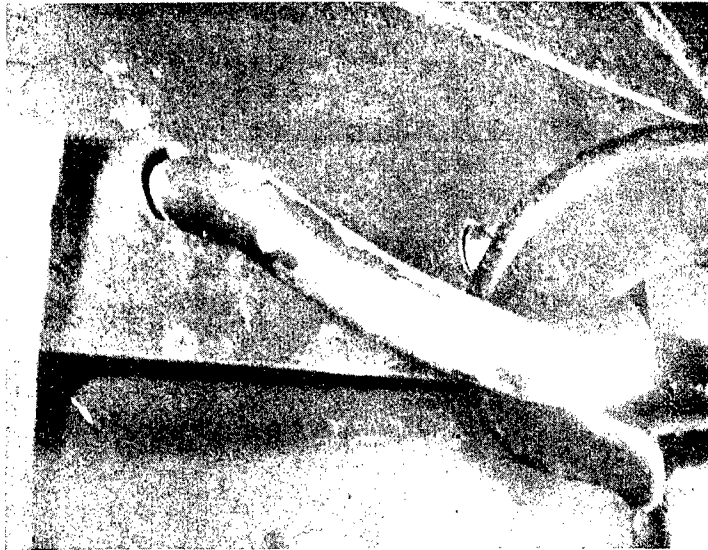
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ML BODY TEST

RIGHT FRONT LOWER TIE
DOWN AFTER 20,000lb. TEST

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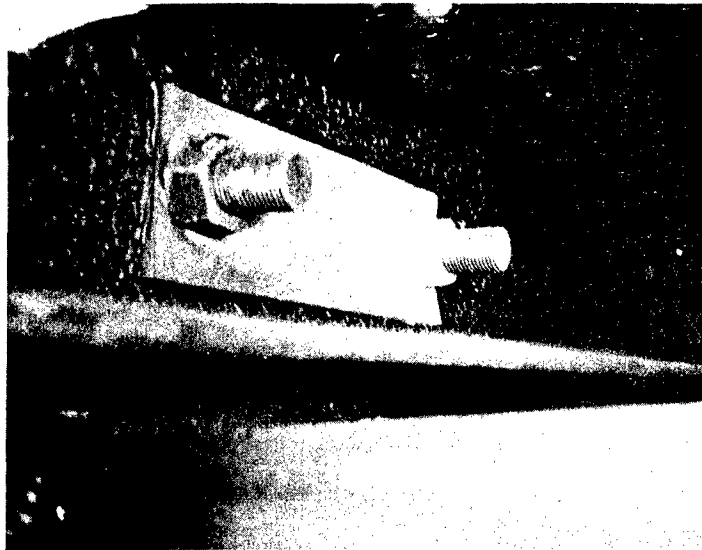


M4 BODY TEST

LEFT REAR LOWER TIE

DOWN AFTER 20,000lb. TEST.

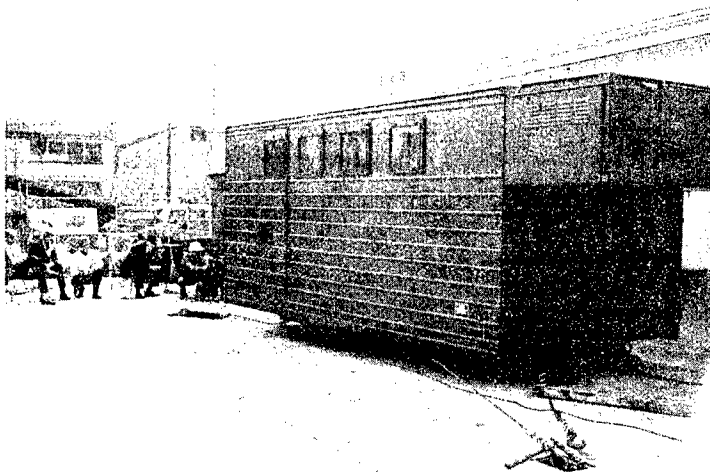
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M4 BODY TEST

BACK PLATE ON RIGHT
FRONT LOWER TIE DOWN
AFTER 20,000lb. TEST.

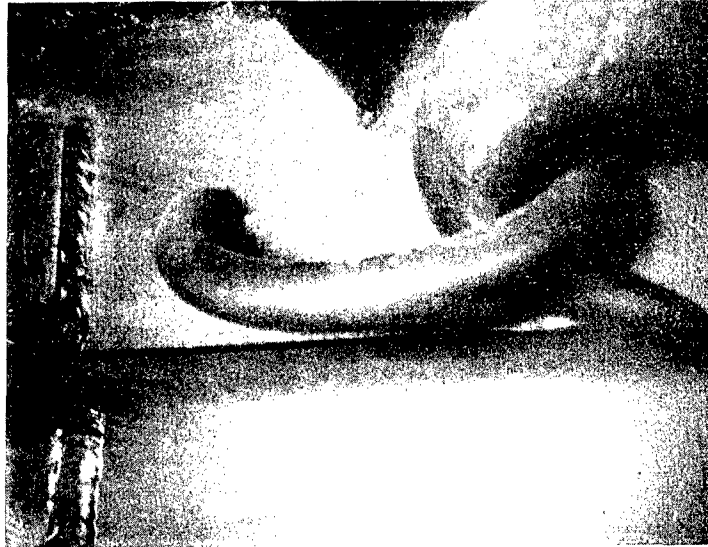
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MILITARY ELECTRONIC DIVISION
333 - 6th AVENUE WEST
BRADENTON, FLORIDA 33505



M4 BODY TEST

LOWER TIE DOWN, RIGHT
CENTER, 20,000lb. TEST.

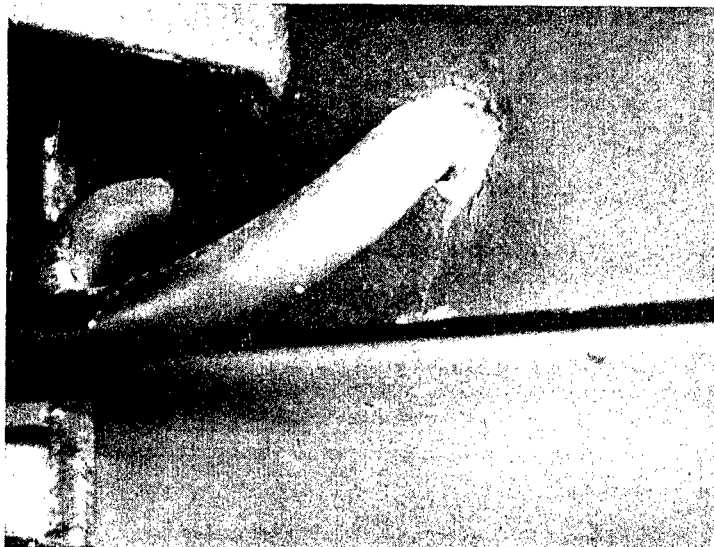
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BRADENTON, FLORIDA 33505



M4 BODY TEST

LOWER TIE DOWN, RIGHT
CENTER, AFTER 20,000lb.
TEST.

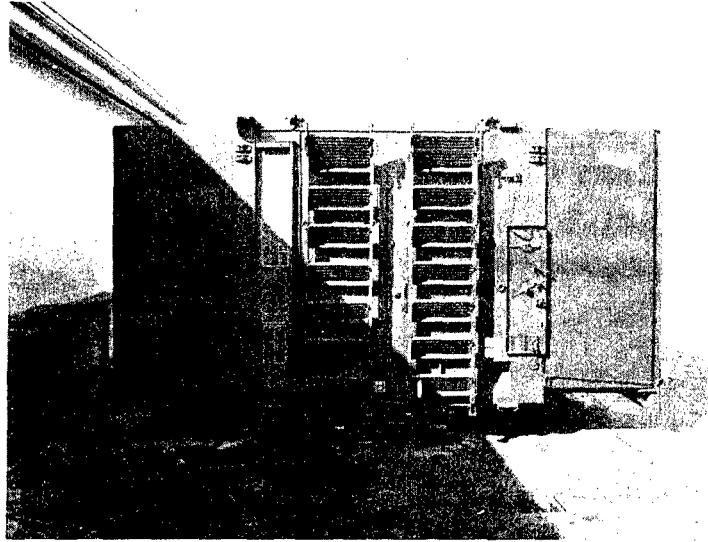
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BRADENTON, FLORIDA 33505



M4 BODY TEST

LOWER TIE DOWN, RIGHT
CENTER, AFTER 20,000lb.
TEST.

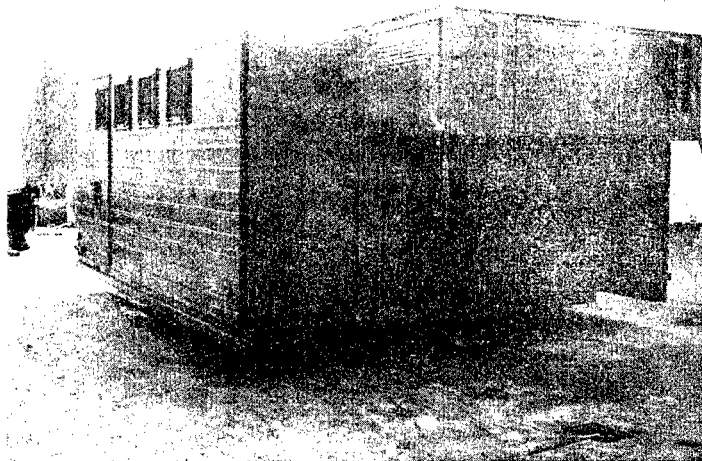
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BRADENTON, FLORIDA 33505



M4 BODY TEST

EXPANDED BODY AFTER ALL
TESTS WERE COMPLETED.

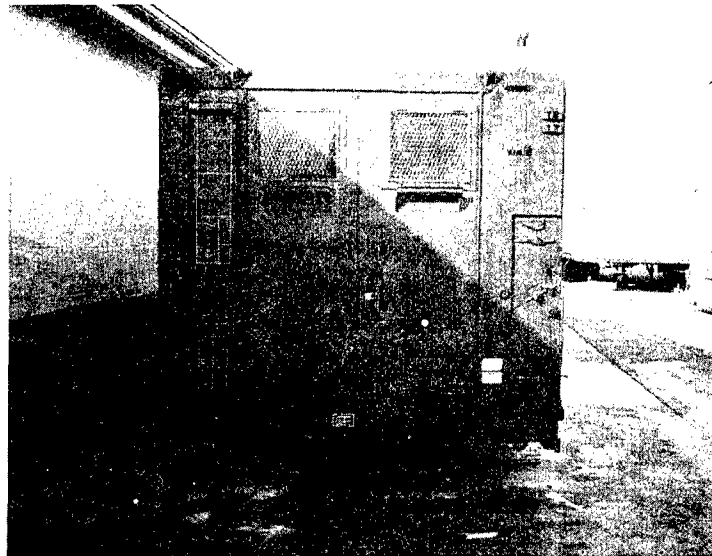
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M4 BODY TEST

BODY EXPANDED AFTER ALL
TESTS WERE COMPLETED.

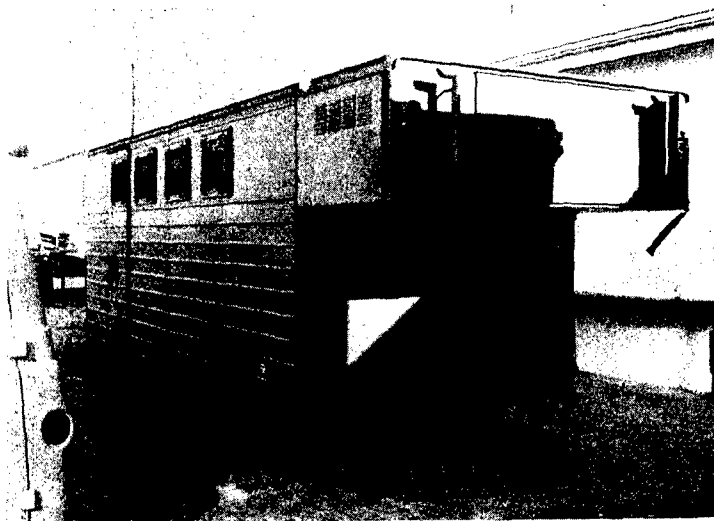
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BRADENTON, FLORIDA 33505



M4 BODY TEST

BODY CLOSED AFTER THE
BODY HAD BEEN EXPANDED
AFTER ALL TESTS HAD
BEEN COMPLETED.

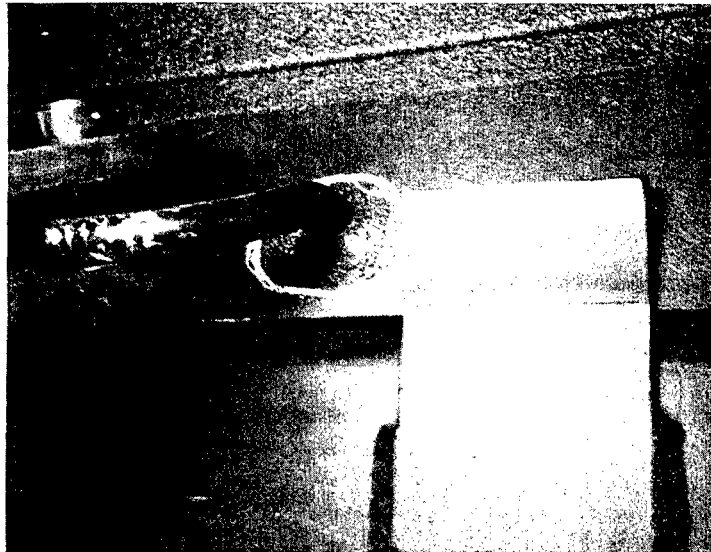
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MILITARY ELECTRONIC DIVISION
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BRADENTON, FLORIDA 33505



M4 BODY TEST

BODY CLOSED AFTER THE
BODY HAD BEEN EXPANDED
AFTER ALL TESTS HAD
BEEN COMPLETED.

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M4 BODY TEST

RIGHT REAR LOWER TIE DOWN SHOWING DISTRESS
AFTER FIRST ATTEMPT TO REACH 20,000LB. TEST
PULL, DURING WHICH ACTUATOR INTERFERED WITH
ADAPTER BRACKET. (BRACKET NOT SHOWN)

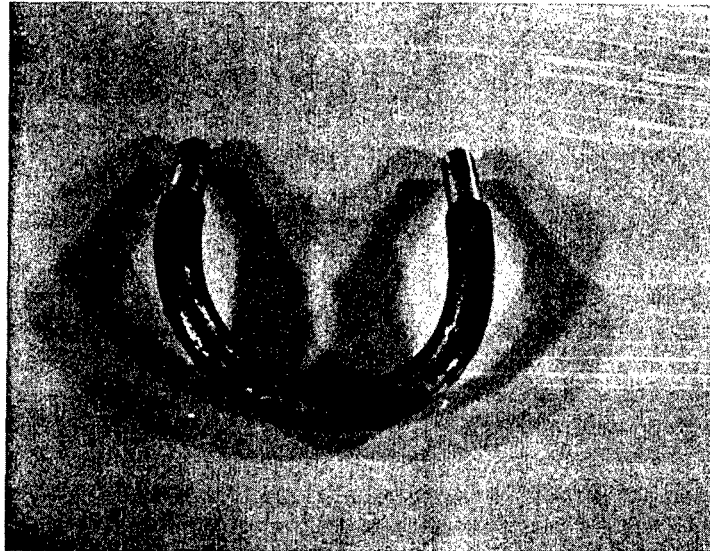
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M4 BODY TEST

DISTORTION IN RIGHT REAR LOWER TIE DOWN
AFTER FIRST ATTEMPT TO REACH 20,000LB.
TEST PULL.

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M4 BODY TEST

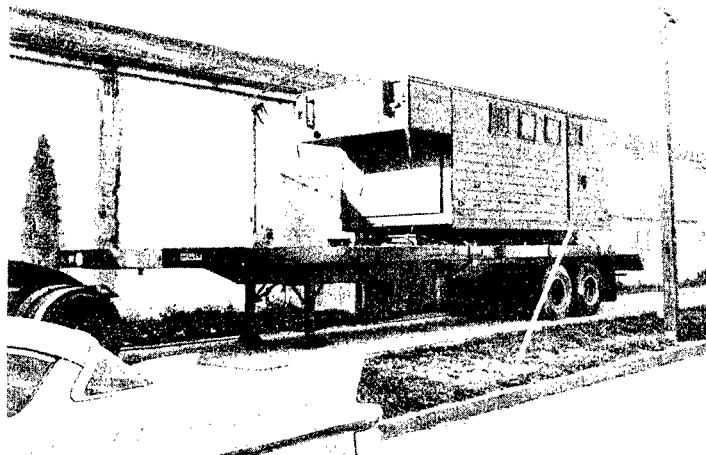
DISTORTION IN LEFT REAR LOWER TIE DOWN AFTER
FIRST ATTEMPT TO REACH 20,000LB. TEST PULL.

MILLER TRAILERS, INC.

MILITARY ELECTRONIC DIVISION

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BRADENTON, FLORIDA 33505



M4 VAN BODY ON SCALES. TOTAL WEIGHT OF VAN
WITH ADAPTER WAS 9,370LBS. THIS WEIGHT
INCLUDED 100' CABLE, CABLEREEL, 2 FIRE
BOTTLES AND WOOD SPACERS. LIFTING SLINGS
WERE REMOVED.

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13. ABSTRACT <p>The van body tie-down test was performed on a smooth, level, concrete slab containing a fixed group of permanent anchors set in the concrete, each equipped with a heavy attaching ring. The four anchors used in the test agree closely with the spacing of tie-down rings in the C-124 aircraft.</p> <p>For the lifting test, sling cables were attached at each end of a longitudinal spreader bar directly over the lifting eyes. Gradually increasing equal pressure was applied through hydraulic actuators. The van floor was loaded with successively greater weights, to simulate 2.0G's.</p> <p>Subsequently, the body sides were opened to full expanded position, and then re-closed. These operations proceeded smoothly, with no evidence of binding.</p>			

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14.	KEY WORDS	LINK A		LINK B		LINK C	
		ROLE	WT	ROLE	WT	ROLE	WT
	Cargo Vehicle						
	Van Body						
	Lifting Eyes						
	Tie-Down Test						
	Lifting Test						

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